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In last No. of "Fulton," page 41, 26th line from top, for "1835," the date of the completion of the Erie Canal, read 1825.

INSTITUTION OF CIVIL ENGINEERS.

Feeling as we do, a deep interest in the formation of an American Society of Civil Engineers, we have always warmly seconded any endeavors to bring about a successful organization of the profession in this country. It has been with us a favorite topic, and in our intercourse with the members of the profession, we have been frequently urged to move in the matter.

During a tour through several neighboring States, we had received so many solicitations to represent the united opinion of a large number of Engineers, as to the necessity for a concert of action throughout the profession, an embodiment of the whole information on subjects connected with Civil Engineering, and a means of occasional but free inter-communication—the true and legitimate objects of a Society of Engineers—that we had resolved to give as far as it was in our power, a view of the desiderata for such an organization, with a *proposed* outline of a constitution, which should be in fact an adaptation of the constitution of the English Institute, to our more extensive country. It was urged that such a measure was necessary to the elevation of the professional standard in the United States; and that being in communication with a large number of Civil Engineers, we could more conveniently obtain an expression of their opinions.

While taking the preliminary steps we, received intelligence of a meeting which proposed a convention for this very purpose. Of course we made no further move in the matter, than to publish the official proceedings of this convention and its committees. We must confess that a convention has always appeared a questionable mode of obtaining a satisfactory organization. Many individuals, who from various circumstances might be prevented from attending, and yet who entertained opinions from which valuable hints might be obtained, are thus excluded from taking a part in any organization which might take place, and would feel a natural indifference towards making any further effort to introduce rules and regula-

tions which they might consider absolutely necessary. Besides this, the effort to connect with institutions already established immediately introduced feelings of party spirit, which should have no place in the formation of a society of Engineers, and which belonged only to those preexisting institutions. Many thought that the Civil Engineers of the United States, thus organized, would become in fact a mere section of some local society. These notions, whether incorrect or not, undoubtedly had an influence.

We had hoped however, that these preliminary difficulties might be avoided, and the project prove successful. Such however, has not been the case. The official reports of proceedings have hitherto been published in this Journal, but although the result was known, we have not, until just now received the official announcement of the non-adoption of the proposed constitution, and consequent termination of all action.

We give, (page 81,) a communication from Mr. Miller, with the final correspondence.

From a perusal of them, we are satisfied that many of the gentlemen dissenting from the proposed constitution, are warmly in favor of an efficient organization, and would willingly unite on the common ground of the improvement of the profession.

Before concluding, we must remark, that there appears to be a mistake as to some of the objects proposed. Although a library, and collection of maps, models, etc., are very desirable, yet at first they are not attainable, and are not therefore to be made prime objects. A much more useful and far more practicable object, is to obtain a concentration of the influence and information of the profession, together with a concert of action. What we want first of all, is, an investigation into the improvement system, as modified by our peculiar circumstances in a national point of view; descriptions and details of individual works; statistics of works in operation; the elements of a judicious, economical and safe system of management of railroads, canals and steamboats, upon which subjects the opinion of an intelligent body of engineers would have the greatest weight, as a basis for legislative action when necessary, but which would go far to do away with any such necessity; and lastly the cultivation of science in all its bearings upon Civil Engineering, in which we doubt not, the members of the profession in the United States are fully able to co-operate with their transatlantic brethren.

These are the ends to be kept in view, and yet to be accomplished with ease, if properly taken up. It is not necessary nor is it practicable that every member shall at any one time be in personal attendance although this occasionally is desirable and not difficult of execution. Members can appear by their communications and receive the benefit of all that is offered without personal attendance.

We give place with great pleasure to the communication of Mr. Miller, and invite attention to the subject with the hope that we shall receive many other communications on the subject, which we shall as cheerfully insert.

For the American Railroad Journal and Mechanics' Magazine.

INTERNAL IMPROVEMENTS OF NEW YORK. NO. 2.

Facts sufficient were adduced in the last number to demonstrate that the enlargement of the Erie canal to the size proposed is not required to accommodate any possible increase in the tonnage passing upon it for some years to come. It was there shown that the business on the western portion of the canal has thus far fallen far short of its capacity.

It was also shown that the revenue from the whole canal had not, up to the date of the last report of the comptroller, been more than sufficient to defray the interest on its cost, together with the expense of repairs and superintendence. This being true of the whole canal, it requires no labored demonstration to show that its western portion is yet *very deeply* in debt to the State for its construction and maintenance, and in this respect is in the same predicament with the lateral canals. Upon the eastern portion, although at one period the business was nearly equal to the ability of the canal with single locks to accommodate, yet as the ratio of decrease in the products of the forest has far exceeded and is likely to exceed for some years that of the increase in the products of agriculture, there is no positive necessity for an enlargement, to accommodate the business that is likely to pass upon it. The correctness of this view of the subject is farther confirmed by the effect which the completion of the line of railway from the Hudson to the Lakes particularly that extending from Albany to Buffalo, will have upon the business of the canal.

The distance from Albany to Buffalo by the canal is	363 miles
By the several lines of railway as chartered it is	320 "
Difference in favor of railway,	43 "

From Albany to Auburn 174 miles, and from Rochester to Batavia 30 miles, making in all 204 miles, the line of railway is completed, and in operation. Of the remaining 116 miles, 78 are under contract, and the remainder will ere long be constructed. The period is therefore, very near at hand, when there will exist a continuous line of railway from the Hudson to Lake Erie parallel with, and for most of the distance situated in the immediate vicinity of the Erie canal.

The effect of the railway thus far has been to drive the packet boats from the canal and to give by the consequent diminution of lockages a relief to the canal fully equivalent to about 30 per cent. of the agricultural products, which, together with the rapid decline in the product of the forest, already explained, will place the period when the canal shall be doing business to the extent of its capacity, still more remote than was stated in my last number

Previous to the construction of the railway the *line* boats, as they are termed, conveyed a great many passengers, and were provided with cabins for their accommodation. This branch of the business is becoming less profitable, and hence more boats in proportion are constructed after the

plan of what are termed the *lake* boats, which are designed for the transportation of freight only. The effect of this change is to enable a less number of boats to convey a greater amount of tonnage, and thus diminish relatively the number of lockages. The locks being the only points where any obstruction exists upon the canal, a very great relief is reasonably anticipated from this cause. Much relief may also be expected from another source. The portion of the product of the forest which obstructs most the navigation, viz. the round and square timber which is conveyed in rafts or floats, is the portion which, in the great falling off in that branch of transportation, will probably most rapidly diminish. If in addition to this, a diminution be made in the tolls upon lumber, the rates being less at that season, viz. in midsummer, when the canal is the least crowded, the transportation of that article may be so regulated as to accommodate other articles requiring a more speedy transit, and at the same time add materially to the capacity of the canal.

That there is a very considerable difference in the transportation upon the canal at different periods of the navigable season there is no doubt. It is certainly desirable to afford every facility for the expeditious conveyance of freight to market. But there is no doubt that by a proper arrangement of the tolls, sufficient inducements may be offered to those interested to alter the periods of transportation of particular articles in such a way as to greatly equalize the business of the canal. Without, however, any such arrangements, there is reason to believe that any extraordinary increase in pressure in the business will be relieved by the line of railway already described.

It is true, indeed, that the legislature in the plenitude of its wisdom has prohibited the transportation of freight on a portion of the line of railroad from Albany to Buffalo, and on other portions exacts a tribute, equivalent to what the State would have received had the freight passed upon the canal. Assuming this policy to be based upon principles which are correct in the abstract, (which is far from being conceded,) there is no good reason why the restrictions may not be removed at those times, when the canal is incompetent to do the business that may be thrown upon it. Such an arrangement would afford great relief to the canal in times of pressure should such times ever occur, and if not found adequate, it is easy to show it to be for the interest of the State, and of all concerned, to *give* to the railroad companies whatever is necessary to induce them to undertake the transportation, rather than incur the enormous expense of the enlargement.

The dimensions of the Erie canal as stated in the previous communication are 40 ft. width at surface and 4 ft. in depth. From information derived from those who navigate it, there are portions of it which do not exceed 3 to 3½ ft. This is owing to the locks not having been excavated to the proper depth in the first instance, or to the subsequent accumulation of mud in the canal or perhaps to both causes combined. As to the fact of an insufficient depth at particular points there appears to be no doubt, and can only

be attributed to unfaithfulness on the part of the original contractors, or to the remissness of the superintendents. This deficiency in the depth, is sufficient to make considerable difference in the capacity of the canal so long as there are portions, however limited in extent where the depth does not exceed 3 to 3½ feet, the depth of draught and consequent load of the boats must correspond thereto, even if the remaining portions have a depth fully equal to or greater than the standard of four feet. For boats of the kind now used in navigating the Erie canal an increase in the load of about 16 tons produces an addition to the depth of draught of about six inches. By giving to the canal a uniform depth of water equal to what was contemplated viz. 4 feet, which may unquestionably be done without great expense, it is easy to perceive that its capacity for business will be much augmented. By this improvement alone the increase in its capacity may safely be estimated at 25 per cent. The capacity of a canal to accommodate the business of a country is limited when the speed of the boats and time of passing the locks are given :—

1. By the depth of its channel.
2. The length and breadth of its lock chambers.
3. By the number of locks.

The length of the lock chambers as already stated on the Erie Canal, is 90 feet. The boats average about 75 or 80 feet in length. By adding to the length of the chambers 15 or 20 feet, which might easily be done without disturbing the present walls or the foundation of the locks, the boats may be lengthened the same amount, and their tonnage increased in the same proportion, giving to the canal a capacity one fifth greater than it now possesses. Upon those portions also where the pressure of business is the greatest, additional locks, if required, could be constructed which when the improvement is made at all necessary points, would, with the other improvements mentioned above, give to the canal a capacity sufficient to accommodate two and a half to three times the amount of trade now conveyed upon it. These improvements could have been made gradually without interfering with the navigation and might have been embraced in the ordinary course of repairs, without necessarily increasing very much the annual expenditures for that object, and thus have left to the State a nett annual revenue to be applied to other objects of undoubted utility of more than half a million of dollars.

As a farther evidence that the canal is not yet doing business to the extent of its capacity, it may be remarked that in prosecuting its enlargement thus far, most of the labor expended upon it has been directed to the erection of the mechanical structures—the materials for which, comprising timber and stone to a great amount, are in almost every instance transported for a greater or less distance on the canal. This great increase in the transportation, which of course is temporary, has caused no sensible inconvenience or obstruction to the navigation, and affords conclusive evidence that when the imperfections in the navigation above described and

remedied the canal will afford abundant accommodation to the business for some time to come.

The remarks thus far made in relation to the probable future business of the canal, have reference more particularly to the trade between the seaboard and the interior. There is another branch of business not the less important, which increases with the population and the development of the internal resources of the State. This is the internal trade of the canal consisting of the interchange of commodities between the several districts through which the canal passes. The canal, stretching as it does through a region of country of more than 300 miles in extent, the different portions of which are characterized by a great difference in soil and climate and in agricultural, mineral and manufacturing resources, there naturally exists an interchange of those productions of each, constituting an extensive internal traffic which will continue to increase. Making, however, all due allowances for the future increase in this branch of business and allowing also for the increase and decrease from the other sources and causes mentioned, we are forced to the conclusion that very many years will elapse particularly if the canal is improved as suggested, before it will be crowded with business to the extent of its capacity.

So far, therefore, as the plea for the enlargement to the great dimensions proposed of 70 feet width and 7 feet depth, and the necessity of expending from 30 to 40 millions of dollars to effect it, is based upon the inadequacy of the canal to accommodate the anticipate dtrade upon it, it has no foundation in fact. How far this vast expenditure is warranted by the other reason which has been assigned in a reduction in the cost of transportation is a question which we shall endeavor to answer in the next number.

FULTON.

For the American Railroad Journal and Mechanics' Magazine.

REMARKS ON THE ABSTRACT OF DR. LARDNERS PAPER "ON RAILWAY CONSTANTS, ETC.," PUBLISHED IN THE CIVIL ENGINEERS AND ARCHITECT'S JOURNAL FOR OCTOBER, 1839.—By W. R. Casey, Civil Engineer.

Dr. Lardner has made a series of experiments to determine the amount of resistance offered to railway trains by the atmosphere, as well as the value of the "friction," the two resistances forming what has generally been called in this country, the "traction." His conclusions are precisely those of Mr. Wood, which Mr. Brunel considered impossible and against which he urged several objections which went to show the incorrectness of Mr. Wood s deductions as well as the little reliance to be placed in his experiments, rather than to point out where the error lay. An attentive perusal of Dr. Lardner's paper led me to examine Mr. Wood's statements and Mr. Brunel's objections more closely, and, though Mr. Brunel failed to point out the grand source of error, it appears to me, that the late experiments of Dr. Lardner fully confirm the views of Mr. Brunel and other practical en-

gineers, and offer abundant proof of the utter fallacy of nearly all his own deductions as well as those of Mr. Wood. In all these papers the experiments are detailed with great minuteness, but the opinions of the writers are given unaccompanied by the reasoning or calculations by which they arrived at these conclusions, so that to decide on their merits we are under the necessity of going through a formal investigation ourselves, instead of merely following them and judging of the accuracy of their mode of calculation.

We will commence with the grand error of Dr. Lardner and Mr. Wood. The latter gentleman states in his Report:—

"The force exerted by 15 6-10ths tons down an inclination of 1 in 96 is equivalent to 364 pounds, and as this was the weight of the train in the first experiments, it follows that such a coach train moving at 31 miles an hour suffers a resistance of that amount, which includes both friction and atmospheric resistance.

Again, the force exerted by 18 ton 1 cwt. down the same inclination is 421 12 pounds, and as the train having this weight moved with a uniform velocity of 32 1-4 miles an hour down the plane, this was its resistance at that speed."

Dr Lardner says:—

"The last experiment with a train of eight coaches, weighing nearly forty tons, shows that, in a dead calm, the resistance of *that train at* 31¼ *miles an hour amounted to the eighty-ninth part of its weight; whereas the common estimate of the resistance of such a train at that speed has been hitherto about the* 250*th part of its weight!* This fact alone, were it unconnected with any others, would sufficiently illustrate the enormous extent of error which has prevailed hitherto in such estimations in railway practice."

Neglecting the difference between the length and base of the inclined plane under consideration as insignificant in its effects, nothing can be more true than, that the ratio of the length of the plane to its altitude represents strictly the ratio of the weight of a body on this plane to the force with which gravity urges or rather draws it down the plane. Consequently a body on a plane whose length is to its altitude as 89 to 1 will (omitting friction) be held in equilibrio with gravity on that plane by a force equal to the 1-89 o its weight—in other words, the force down the plane is equal to the resistance, and both are equal to 1-89 of the weight of the body left free to the force which gravity is able to exert on an inclination of 1-89.

Now, what is the result of gravity in the experiment just quoted from Dr. Lardner's paper? The force of gravity on an inclined plane of 1-89 or, which is the same thing, the 1-89th part of the weight of the 8 coaches (40.75 tons) *generates and keeps up a velocity of* 31-4 *miles per hour*, overcomes the friction and the resistance of the atmosphere. Dr Lardner and Mr. Wood consider the entire force of gravity to be expended in counteracting the two latter resistances, and entirely overlook that portion of the force or of the height of the plane which generates and keeps up the velocity. Suppose at the foot of the plane of 1-89 another plane inclined in the opposite direction, then the train of coaches descending with a velocity of 31-4 miles per hour would ascend this second plane till the momentum derived from the first plane was destroyed by the counteracting force of gravity on the second, and it is the *difference* between the height of the starting and stopping points on these two planes, not the absolute height of the first nor yet its angle of inclination, which expresses the resistances from friction and from the air. It will readily be observed, that this rea-

soning supposes the coaches to start from a state of rest, and that the length of the first plane does not exceed that required to generate the maximum velocity on that inclination. All this is admirably explained in the inexhaustible and incomparable work of de Pambour; but another illustration may not be unacceptable. If we knew the distance down a plane of given inclination, over which a train of cars must pass to attain the maximum velocity which gravity is capable of generating on that plane, it would be easy to determine what part of the height of the plane was due to the velocity, and the remainder would of course give that due to the friction and resistance of the atmosphere. This was not necessary in de Pambour's method, and Dr. Lardner and Mr. Wood merely ascertain the maximum velocity which a certain inclination can produce, immediately inferring that the resistance at that velocity, is as the height of the plane to its length. Careful experiments would be necessary to furnish the necessary data to determine the absolute value of the resistance by the method proposed, but in the absence of these, the principle can be explained by means of one of de Pambour's experiments, (Chap. III. Sec. 4.)

The plane, on which the experiments were made, descends 34·61 feet in a distance of 3300 feet at the rate of 1 in 95·3 or 55·4 feet per mile, after which it only falls 4·47 feet in 7,920 feet. The first 3300 feet evidently form the distance, by passing over which, the train acquires its velocity, while the small descent from the foot of the 1 in 95·3 aids in diminishing the effect of gravity and the other resistances in bringing the train to a state of rest. Now, the *average* velocity, deduced from the time of starting to stopping, was 12 miles per hour, and, were the resistance of the atmosphere, like that arising from friction, constant, the maximum velocity might be assumed at 24 miles per hour, but we will assume 25 per hour, as the velocity generated by descending an inclination of 55·4 feet per mile a distance of 34·61 ft. in the vertical, and consequently 95·3 times that distance or 3300 feet in the horizontal direction.

A velocity of 25 miles per hour is equal to $36\frac{2}{3}$ feet per second and "the height due to this velocity," calculated by the well known formula $s=\frac{v^2}{2g}$ is 20·8 feet. That is to say, a body must fall from a state of rest through a space of 20·8 feet to acquire a velocity of $36\frac{2}{3}$ feet per second, or, which is the same thing, must descend an inclined plane whose height is 20·8 feet, the length of the plane being immaterial, for we are neglecting the resistances of friction and of the atmosphere. We will therefore suppose the length of this second plane to be also 3300 feet; then we have two planes of equal length, the one 34·61 feet high and capable of generating a velocity of $36\frac{2}{3}$ feet per second, *besides* overcoming the resistances of friction and of the air; the other 20·8 feet high also capable of generating a velocity of $36\frac{2}{3}$ ft. per second where these resistances do not exist. Subtracting therefore the height of the second plane 20·8 feet from 34·61 feet, the height of the first, and there remains 13·61 feet = 1·242 of the height

of the plane, =1·242 of the force down the plane, as the value of that part of the force of gravity which is exerted in overcoming the resistances of friction and air, the remaining portion, or 20·8 feet,=1·158 of the force down the plane, being expended in generating the velocity of 36·66 feet per second. According to Dr. Lardner and Mr. Wood the *entire* force of gravity down the plane was required to overcome the resistances, for, though their experiments were not similar to this, it is just as evident that a certain degree of force is necessary to *keep up* as to *generate* motion. The professional reader will see at a glance that the *assumed* velocity of 36·66 feet per second, or 25 miles per hour, may or may not be true, may be more or less, without in any degree affecting the general principle. The mere ratio of the height to the length of the plane and the velocity which gravity can generate on that plane are not sufficient to determine the value of the resistances, for the force of gravity not only overcomes these resistances, but creates a momentum equal to the weight of the body multiplied by the velocity, and it is this momentum which de Pambour subtracts from the whole height of the plane, the remainder being the value of the resistance.

We have just seen, that by assuming 25 miles per hour as the maximum velocity of a train of cars, descending from a state of rest, through a horizontal distance of 3300 ft. on an inclined plane of 1 in 95·3, the value of the retardive forces are 1·242, and the value of the accelerating force of gravity is 1·158 of the force down the plane, or expressing them in terms of the height of the plane, are as 13·61 ft. and 20·8 ft. respectively, instead of the former alone being represented by 33·69, or 2·5 times greater than the value deduced from the rough approximations introduced to simplify the explanations by means of numerical quantities.

Great as is the difference between this hypothetical case and Dr. Lardner, we shall, however, find that experiments on a large scale, or "facts," show that the actual difference is much greater.

Before referring to De Pambour, it may not be improper to state, that the only experiment of Dr. Lardner, from which any approximation can be made, is that in Table VIII, where a descent of 180 ft. carries the train 44,193 ft., at an average velocity of 19·6 miles per hour; thus giving the total resistance $=\frac{180}{44193}=\frac{1}{245\cdot3}$. It is evident, however, that the total actual resistance must have been less than this, for a *uniform* velocity was attained on the 1-177, consequently that portion of the height of the plane *below* the point where the maximum velocity was acquired should be subtracted from the total descent. This most important point is, however, not given. De Pambour, with his usual sagacity, started his trains from a point only 50 chains from the foot of the plane and, as the total distance run by them is only two-thirds of that run by Dr. Lardner's trains, it is clear that the former on arriving at the foot of the plane had *not* reached their maximum velocity, while the latter, even when starting from a state of rest, acquired the very same velocity as when commencing the descent of the plane with

a speed of 30 miles per hour. I will also here observe, that de Pambour's *formula* is, to use Dr. Lardner's language, "founded on the supposition that the resistance is independent of the speed," but, in making the *experiment*, the resistance of the air on the descending, or accelerating plane is *nearly* counteracted by the resistance of the air on the almost level or retardive plane, and indeed Dr. Lardner himself fully acknowledges this principle when advocating his undulating railway and to which we shall subsequently refer.

In the third chapter of De Pambour we find that an engine, tender and 17 cars, in all 94·96 tons, ran over a distance of 11,262 ft.; the vertical difference between the termini being 39·10 ft.; thus giving $\frac{1}{288}$ of the weight or 7·78 lbs. per ton (2240 lbs.) or 18·3 ft. per mile, as the value of the friction, atmospheric resistance, resistance of the working parts of the engine, resistance occasioned by the 9 switches, besides that arising from the irregular motion of the carriages, when, instead of being drawn by the engine with the connecting bolts tight and the carriages comparatively steady, each individual carriage is subjected to the action of gravity, and, as their resistances are all different to a continued series of jerks and pushes, which would altogether justify a diminution of the resistance, in ordinary cases, to less than 7 lbs. per ton of the load, exclusive of the engine. After deducting the ascertained friction of the engine in the above case, the total resistance of the load was 7·21 lbs. per ton, at an *average* velocity of 12 miles per hour, and, as the resistance of the atmosphere increases as the square of the velocity, there will be some loss on account of the difference in the time during which the train runs down the 3300 ft., and that during which it comes from its maximum velocity to a state of rest on the nearly level distance of 7,962 ft. All these considerations point to a lower value of the total resistance, at an average speed of 12 miles per hour, than 7 lbs. per ton. In the experiment just quoted from De Pambour, all the retardive forces were encountered, except that arising from the "additional friction" of the engine, when drawing a load on a level or up an inclination, and it is not improbable, that the increased steadiness owing to the tightness of the connecting bars may be equivalent to this trifling resistance.

The details of an experiment with a very large load were given in the Railroad Journal. Vol II, New Series, p. 187, from which the narrators, Messrs. W. S. Campbell and Ross Winans, Civil Engineers, deduce the entire resistance as less than 7 lbs. per ton on a level with a velocity of 20 miles per hour. Unfortunately, however, there is a discrepency which I find impossible to reconcile, without supposing certain attendant circumstances which should not have escaped professional observers. It appears from the following quotation, that with the steam *on*, the velocity was uniformly 1 mile in $3\frac{1}{4}$ minutes for 2 consecutive miles, then, with the steam shut *off*, the next mile was passed in 3 minutes; so that curvature or the wind or some derangement created a resistance which, with the friction etc., the engine was able to overcome at the rate of 1 mile in $3\frac{1}{4}$

minutes, and this being removed, the train acquired an increase of speed, without *any* steam; the inclination being 18 ft. per mile throughout.

"With the valves in gear, the engine, when the steam was admitted to the cylinders proceeded, without slipping or any other interruption, to put the whole train in motion; and after passing over a level of 800 feet, entered a grade descending 3 7-10 feet per mile, of performing the first mile in 6 minutes; the 2d mile in 4½ minutes; the 3d mile (the grade having changed to 18 feet per mile) in 3 1-4 minutes; the 4th mile 3 1-4 minutes. When the road being perfectly straight, and still descending at the rate of 18 feet per mile, the steam was shut off with the view of ascertaining the influence of gravity on the velocity of the train. In this manner the 5th mile was performed in 3 minutes, showing an accelerated velocity, and that the resistance of the train, even at a velocity of 20 miles per hour, was less than 8 lbs. to the ton,

The resistance from friction, when a train is equilibriated, on an inclination of 18 feet per mile, would be about 7-64 100 lbs. per ton. but as the train was accelerated, it is obvious that the resistance to traction on the Reading road is less than 7-64 100 lbs. and probably not more than 7 lbs. per ton."

Dr. Lardner says in the "abstract:"

"From this and the former experiments, it may therefore be inferred that the mere form whether of the front or hinder part, or the mere magnitude of frontage, produces no practical effects upon resistance; but that, by increasing not the frontage only, but the *whole volume* of the train, a material effect is produced.

It had been found contrary to what was first expected, that by increasing the number of carriages in the train, that portion of the resistance which must be ascribed to the atmosphere was increased. It appeared at first view, that the chief, if not the only source of atmospheric resistance was to be found in the frontage or maximum transverse section. The experiments, however, are entirely incompatible with any such supposition. Had such been the case, the trains of six and eight carriages ought to have acquired a considerably greater velocity in descending the inclined planes, than the trains of four carriages, which was not the case."

"It has been stated confidently in print and at public meetings, by men reputed to possess information in practical science, that the atmospheric resistance has long been known, not perhaps with perfect accuracy, but that tables, giving a near approximation, have been published by different eminent men. and are to be found in most elementary works; that calculations founded on these tables, of the resistance of the atmosphere may be made, and that such calculations would give more correct results than such experiments as have now been described. As such statements are calculated to mislead, Dr. Lardner had no hesitation in declaring that they are utterly unfounded. No details exist, nor have any experiments ever been made by which the resistance of the air to a train of railway carriages could be obtained by any calculation whatever; nor was the amount of such resistance ever suspected, even by the persons who have ventured to utter such statements, as have been here proved to exist."

We will apply the ordinary rules used by "men reputed to possess information in practical science," to the only experiment Dr. Lardner made to determine the effect of frontage, Table IX; for in the experiment recorded in Table V, the frontage of the coach is not given.

The uniform or maximum velocity on 1-177 with a frontage of 24 square ft. was 22·75 miles per hour, and with a frontage of 47·8 square ft. 17 miles per hour; and the velocities at foot of 1-265 were 19·5 and 8·5 miles respectively. Now, $\overline{(22{\cdot}75)^2 \times 24}$ is to $\overline{(17)^2 \times 47{\cdot}8}$ as ten to eleven nearly, a very close approximation in such a case: and $\overline{(19{\cdot}5)^2 \times 24}$ is to $\overline{(8{\cdot}5)^2 \times 47{\cdot}8}$ as 26 to 10. Other experiments, however, are just as contradictory; for instance, in Table I, a load of 27·5 tons descends a plane of 1-89 at the rate of 32·3 miles per hour, with an *adverse* wind, and a load one half greater, 40·75 tons, descends the same plane at the rate of only 31·4 miles per hour in a *dead calm!* These discrepancies prove, not the absence of proper care in conducting the experiments, but that the resistance of the air has so little influence on railway trains under ordinary circumstances of wind, load and speed, that it is difficult to determine it experimentally; and I believe that it has for the last 7 or 8 years been much oftener over-estimated than underrated.

I am under the impression, that the traction might be determined with considerable accuracy by merely adding to De Pambour's observations that of the velocity at the foot of the plane, and then calculating the height due to the velocity as already explained. We have seen that an experiment of De Pambour's gave the value of *all* the resistances at 7·78 lbs. per ton, or, $\frac{1}{310}$ of the weight of wagons, tender and engine, determined on the established principle in mechanics, of "virtual velocities." In attempting to illustrate a somewhat different mode of applying the same principle to this experiment, the velocity acquired by descending 34·6 ft. on an inclination of 1 in 89 was assumed at 25 miles per hour, which gave the traction $=\frac{1}{214}$ of the load on a level, while the experiment gave only $\frac{1}{310}$. The velocity at the foot of the plane was probably 28 or 30 miles per hour, which would give the resistance per square foot of frontage equal to about 4 lbs. The lower parts of the engine reach within a few inches of the rails and the column of air, obstructed by the engine and the first coach which is generally 8 ft. high, cannot well have a less transverse section than 48 or 50 square feet, making the entire resistance in calm weather=200 lbs. at the maximum velocity, or, taking 20 miles per hour as the speed offering the *average* resistance,=100 lbs, and, assuming only $\frac{1}{2}$ this resistance for *all* the other wagons, that is $\frac{1}{17}$ for each, we have a resistance of 150 lbs., or nearly 2 lbs. per ton, which, deducted from 7·21, leaves the friction=5·21 lbs. per ton, or, entirely omitting all atmospheric resistance, except that due to the frontage (100 lbs.), the friction will be about 6 lbs. per ton.

On Dr. Lardner's hyphothesis, that "mere magnitude of frontage produces no practical effects upon resistance, but that by increasing not the frontage only, but the *whole volume* of the train, a material effect is produced," the calculation would be thus:—we *know* that the atmospheric resistance is very nearly $\frac{1}{2}$ lb. per square foot at 10 miles per hour, that it increases rather faster than the square of the velocity, as $(.)^{2\cdot06}$, and that it also increases somewhat with the surface; hence, at 20 miles per hour, with a frontage of 50 ft. we are *sure* that, in calm weather, the atmospheric resistance will be 100 lbs. Now, add to this the resistances of the other 16 carriages estimated at only 50 lbs. each=800 lbs., add the 100 lbs. for frontage, and we have the total resistance, from the air alone equal to 900 lbs. even supposing it to increase only *half* as fast as the volume of the train, when the entire resistance was *determined* by actual trial not to be more than 620 lbs.

There is yet another way of proving that the resistance is as the frontage. Dr. Lardner, in Table I, cites one experiment where a side wind reduced the speed from 26 to 17 miles per hour; but this must have been a very moderate wind, as it has been known for years, that a strong side wind will nearly stop a train, when, with the same wind ahead, the resistance is comparatively slight. This is because the side of a train offers from 20 to 60 times the surface of the transverse section, and *proves* that

the atmospheric resistance increases with the frontage. The *magnitude* of the train is the same in both cases, consequently the resistances should be equal, yet Dr. Lardner's single experiment shows a difference of one-half, with, probably a very moderate wind. That the resistance is as the frontage, has been determined by actual experiment, as well as its value and law of increase *very nearly*—indeed, for all practical purpose, in railroad engineering, this subject may be considered as thoroughly understood.

Without presuming to claim any thing more than a very rough approximation to the truth by these ordinary modes of calculation, they are yet quite sufficient to point out the extraordinary errors of Dr. Lardner and Mr. Wood, and had these statements not been issued forth with such confidence as to lead many implicitly to believe in them, or, had Mr. Brunel pointed out the great source of error, I should not have dwelt thus long in endeaving to show, that Dr. Lardner has signally failed in his attempts to prove, that the resistance of the atmosphere has been *underrated*, that the *frontage* is unimportant, and that the resistance increases as the *volume* of the train.

It is well known that, beyond a certain speed, even a very small increase of velocity is attained with the greatest difficulty, and this has led many to believe, that the resistance of the atmosphere was the retarding cause. M. de Pambour, in August last, attained a velocity of 55·4 miles per hour (R. R. Journal, Dec. 1839, p. 384,) on the Great Western railway, with an engine having wheels 7 ft. in diameter drawing the *tender only*, and was unable to go beyond this, *because*, the pump could not feed the boiler; and it will be found in all cases, that the difficulties in reaching great velocities are owing to the *proportions* of the different parts of the engine being regulated with a view to average work, and not to isolated performances. An engine capable of exercising a power of traction of 800 lbs. at 20 miles per hour, could very easily be geared so as to maintain a uniform velocity of 100 miles per hour on a straight road, but would be of no *use*.

The entire subject is more curious than useful, or even interesting, and, as from variations in the course of the wind, and changes in the direction of the road, the current of air acts almost always obliquely, the angle of incidence must be introduced into the calculation, the spaces between the carriages must be considered, the ratio of the retardation to the pressure of the flanches against the rails must be ascertained experimentally, and, in short, the investigation must, if possible, be as tedious, and embarrassing, as its results must be useless in practice, and vapid in perusal.

Dr. Lardner mistakes friction for "traction," in which latter sense it is always used by de Pambour, for, in assuming the "friction" at 8 lbs. per ton, he, (de P.) means that to represent the average *total* resistance of an ordinary train, say 40 to 60 tons, moving at the rate of about 20 miles per hour. By taking a larger train, 86 tons, and applying the ordinary calculation we have seen, that it leaves the friction at 5 or 6 lbs. per ton, the same

result as that obtained by Dr. Lardner, Mr. Wood, and Mr. E. Woods the engineer of the Liverpool and Manchester railway.

We have, however, much better proof here of the actual value of the friction, properly so called. For the last three or four years, fire wood has been carried on the Lowell railway on trains of 6 or 8 cars, descending grades of 8 and 10 feet per mile for the distance of 4 or 5 miles by the force of gravity only, *after* being set in motion at the head of the inclination. This I state on the authority of Charles S. Storrow, Esq., the engineer of that railway, to whom I am indebted for a letter containing some other particulars of the work, but as he informs me, that he intends, during the ensuing summer, to make some experiments on this subject as well as to give a detailed account of the peculiar construction of the road, all I could now say would only serve to detract from the interest of the communication we may expect from one of our ablest and most accomplished engineers, without in any degree aiding the present discussion.

As the cars do not stop on the inclination of 8 ft. per mile$=\frac{1}{660}=3{\cdot}4$ lbs. per ton nearly, the friction cannot exceed that proportion. The cars are loaded with 2 cords of wood each, which would present a frontage of about 32 square feet and, including the platform and wheels, in all about 40 square feet. This, with a velocity of 5 or 6 miles per hour, would create a resistance of about 5 lbs. or 1 lb. per ton for the *first* wagon, and with a velocity of 20 miles per hour would create a resistance of 80 lbs. or 16 lbs. per ton for the first wagon or $2\frac{2}{3}$ lbs. per ton for 6 wagons of 5 tons each. Adding to this the 3·4 lbs for friction and we have 6·06 lbs. per ton for the friction and atmospheric resistance, supposing the 5 wagons, next to the first, to be in *no degree* retarded, which appears impossible. Now, if for this latter consideration and the jolts which will occur on the best roads at great velocities we allow 1 lb. per ton only, we have 7·06 lbs. per ton for the traction on the Lowell railway at the rate of 20 miles per hour. This is only one pound more than estimated by de Pambour 5 or 6 years since.

With a speed of 31·5 miles per hour, and a frontage of 40 square feet, the resistance of the air in a calm will be 4·96 lbs. per square foot or 6·61 per ton for a load of 30 tons, and, adding the friction 3·4 lbs. per ton,$=10{\cdot}01$ lbs. for the traction, entirely omitting the resistance of all except the first wagon; or 11 lbs. per ton if we allow $\frac{1}{10}$ of the resistance of the first to each of the other 5 wagons. This is $\frac{1}{103}$ of the weight instead of $\frac{1}{90}$ as assumed by Dr. Lardner. There is consequently no difficulty in accounting for the common estimate of from 9 to 11 pounds per ton, with velocities of from 20 to 30 miles per hour by the ordinary mode of calculation.

It may not be improper to add, that the Lowell railway is considered by many, including G. W. Whistler, Esq., our most experienced railway engineer, as superior to any other road in New England and, "a fortiori," to all others in the United States;—for Old and New England are the only

parts of the old and new worlds where the railway feels, as yet, "at home."

Dr Lardner says:—

"That a railway laid down with gradients, from sixteen to twenty feet a mile, would be for all practical purposes nearly if not altogether, as good as a railway laid down, from terminus to terminus, upon a dead level. The grounds on which he advanced this doctrine were, that a compensating effect would be produced in descending and ascending the gradients, and that a variation of speed in the train would be the whole amount of inconvenience which would ensue; that the time of performing the journey, and the expenditure of power required for it, the expense of maintaining the line of way, and supplying locomotive power, would be the same in both cases; that, therefore, he thought that no considerable capital ought to be expended in obtaining gradients lower than those just mentioned. He stated that he was assailed with the most unsparing ridicule when he advanced this doctrine, and that up to the present hour, so far as he knew, it had never been adopted or assented to by any practical man in the country.

One of the strongest objections urged against Mr. Brunel's gradients was, that, with the loads and velocities of practice, any diminution of gradients below the angle of friction was not attended with sufficient advantages to justify the additional expenditure, and the London and Birmingham railway was quoted as an example. On this latter road the principle was fully adopted and carried out by Mr. Stephenson, and has been repeatedly advocated in this country, on the ground, that the greatest load in practice should not exceed one half the *maximum* power of the engine. This is only one of those thousand circumstances which influence the engineer in his final decisions, and of which he is not to be held ignorant, because he has neither time nor inclination to write long treatises on them.

"The speed in ascending and descending the several gradients and the mean between them is exhibited in

TABLE X.

Gradient.	Speed.		
	Ascending.	Descending.	Mean.
One in	Miles per h.	Miles per h.	
177	22·25	41·32	31·78
265	24·87	39·13	32·00
330	25·26	37·07	31·16
400	26·87	36·75	31·81
532	27·35	34·30	30·82
590	27·27	33·16	30·21
650	29·03	32·58	30·80
Level			30·93

"He said, that on this table it is scarcely needful to make a single observation. It is quite evident, that the gradients do possess the compensating power which he ascribed to them. The discrepancy existing among the mean values of the speed, is nothing more than what may be ascribed to casual variations in the moving power. This experiment also was made under very favorable circumstances, the day being quite calm. Without going into the details of the principle on which these remarkable results depend, it may be stated generally, that since the chief part of the resistance of a railway train depends on the atmosphere,

and is proportional to the square of the velocity, a very small diminution in the velocity itself produces a considerable diminution in its square. A train, in ascending a gradient, may therefore relieve itself from as much atmospheric resistance as is equal to the gravitation of the plane by slackening of its speed."

This is a mere corroboration of de Pambour's mode of assertaining the total resistance to a train in motion. Now if, on a plane of 1-89, the entire force of gravity be absorbed in overcoming the resistance, as previously assumed by Dr. Lardner, whence is derived the power, which, by carrying the train up the next plane, so very nearly compensates for the power expended in the descent of the first?

As for the "chief part of the resistance of a railway train depending on the atmosphere," we have seen, that well known and well established modes of calculation explain all with sufficient accuracy; the experiments of de Pambour with locomotives, give us the value of the power, and his experiments with the wagons, give us the traction; we have, therefore, the power and the weight determined by different methods, and they correspond with nearly all the accuracy the case admits. Hence, if the entire resistance has been so much underrated, the power of the engine and the value of the adhesion have been underrated in the same proportion, and we must of course infer, that all who have hitherto written on this subject, including de Pambour, are entirely in error. That the latter gentleman differs widely from Dr. Lardner, is very true, but that he is in error, on that account, is not, in my opinion, a logical deduction.

A variation of speed from 20 to 40 miles per hour, is spoken of as the "whole amount of inconvenience." "Inconvenience" is a very mild term for the enormous difference in the dividends, which such differences in speed would make. The wear of engines, road, coaches, and the increased liability to accident must be from 6 to 10 times greater at a speed of 40 than of 20 miles per hour. By making the road consist of a series of cycloidal arcs, the "compensating power" will be retained, there will be, in addition to this, a saving in time, and, as no engineer ever did or ever will adopt this plan, it will form a "constant" on which to "enlarge." when alluding to the obstinacy of "practical men" in neglecting the advice of "men of science."

I shall make only one more extract.

"When the first experiments indicating these results became public, various objections were urged against them, by Mr. Brunel; and although it was not considered by Dr. Lardner, or by any of the other persons engaged in this inquiry, that such objections were entitled to any serious attention, yet it was thought advisable to make experiments which would show whether or not they had any foundation in truth."

On this I shall merely observe, that the credit to which Dr. Lardner is entitled for his very extensive course of experiments, will be somewhat lessened by his disparaging allusions to Mr. Brunel, as well as by his assertion, that the statements of "men reputed to possess information in practical science," the foremost being de Pambour "are utterly unfounded."

For the American Railroad Journal and Mechanics' Magazine.

GENTLEMEN:—I enclose you two circular letters on the subject of a Society of Civil Engineers, which a due respect for the Convention that met at Baltimore last spring, requires me to publish—in connection with the documents already printed in the Railroad Journal, (Vol. 2, New Series, pages 153, 193, and 225,) they complete the history of this abortive attempt to establish a society.

I have delayed the publication of these papers, under the impression that the Committee of seventeen might, perhaps, take further action on the subject. They have not done so, however, and I therefore am justified in considering the measure abandoned.

The members of the Baltimore Convention have a right to be officially informed of this fact, in order that they may be at liberty to adopt such further measures as they may deem necessary.

My position as a member of the Committee, and its Secretary, caused me to devote considerable attention to the subject; and I am fully satisfied that the appointment of a large Committee for this purpose, by the vote of a general Convention, (although certainly a very *democratic* mode of proceeding,) was by no means that likely to produce harmony in council, or the greatest benefit to the profession and science. When to this is superadded the facts, that most of the individuals composing the committee were ignorant of their appointment, and of course unable to promise attendance; that several of them were absolutely indifferent or hostile to the formation of any Institution, which could fulfil the objects proposed by the Convention; that many of them were personally unknown to each other; and that they were scattered over such an extent of territory, as to render a general meeting very difficult, and an epistolary discussion so tedious and troublesome as to be almost out of the question; there can hardly be a necessity of pointing out the local views, partialities and jealousies, which influenced in some measure the result.

I must confess that my own views on this subject have undergone considerable modification, and I am by no means satisfied that a grand National Society is at present either practicable or desirable. The members of the profession are so widely scattered, and have generally so little command of their own time, that even an annual session would be but thinly attended, and the advantages resulting from the collections of plans, models, reports, books, and manuscripts, (which appears to me among the main objects of the Association,) would be almost exclusively local.

The management, too, of a National Society must necessarily rest in a few hands, and those on account of convenience in consultation and action, should reside near the point where the Society's hall is located. This will cause jealousy and discontent.

Cannot the object aimed at be reached by the formation of four independent Societies, having their points of meeting in different portions of the Union, and their sessions at different seasons of the year?

A properly authenticated certificate of membership from any one of them might then by common consent, entitle the holder to a participation in the proceedings and privileges of the others, (with the exception of voting, etc.;) and thus, those whom leisure and inclination permitted, might attend a quarterly meeting of Engineers, instead of an annual one, and listen to the voice of experience from every quarter.

These societies would emulate each other in the advancement of scientific and practical knowledge; and although less imposing in their title and character, than one nominally combining the talents of the nation, in the aggregate they would be vastly more useful; for numbers of excellent Engineers would participate in their advantages, who would be debarred by the expense and time incidental to a long journey, from attending the annual meeting of a National Institute.

The following, would perhaps, be considered a convenient division of the Union.

1. New York and New England.
2. Pennsylvania, New Jersey, Maryland, Delaware and Virginia.
3. All the States south of Kentucky and Virginia.
4. Kentucky and the North Western States.

I shall be glad to see a full discussion of this important matter in your Journal. And am very respectfully,

EDWARD MILLER, *Civil Engineer.*

Philadelphia, January 15, 1840.

CIRCULAR NUMBER ONE. ADDRESSED TO EACH MEMBER OF THE COMMITTEE OF SEVENTEEN.

PHILADELPHIA, April 27, 1839.

Sir :—The same mail which will bring you this letter will also transmit you a printed copy of the proceedings of the Committee, appointed by the Baltimore Convention, for the purpose of organizing a Society of Civil Engineers, and adopting a constitution for its guidance.

It is to be regretted that so small a number of the committee attended the meeting in Philadelphia; though perhaps the six who met, (representing each a different State,) may be considered as affording a fair indication of the feelings and wishes of the profession throughout the Union.

The approval of a majority of the whole seventeen is required in order to adopt the constitution, and, therefore, in accordance with Section XV, I solicit you to peruse the document, and send me at your earliest convenience a notice of your approval or disapproval of the same.

I have to regret the occurrence of three errors in the printed copy, of some importance. The first is in Section II, Par. 5. Add at the end of this paragraph the following sentence, "*Consisting of seven members.*"

And in the list of names added to the original seventeen, Section XVI, for M. R. Stanley, read M. R. Stealey; and for T. M. Fessenden, read John M. Fessenden.

I am, very respectfully, your obedient servant,

EDWARD MILLER.

Secretary of Committee of Seventeen.

Residence No. 246 *Spruce St. Philadelphia.*

CIRCULAR NUMBER TWO, ADDRESSED TO EACH MEMBER OF THE COMMITTEE OF SEVENTEEN.

PHILADELPHIA, July 30th, 1839.

Dear Sir:—I have the honor to inform you that the form of constitution proposed for the Society of Civil Engineers by that portion of the Committee of seventeen which met in Philadelphia on the 10th of April last, has failed to receive the votes of a majority of the Committee, and must therefore be considered rejected.—

The votes are as follows, viz.:—

7 *Approving*,—Benjamin Wright, Wm. S. Campbell, Charles B. Fisk, Edward F. Gay, Edward Miller, Moncure Robinson, and J. Edgar Thomson.

6 *Disapproving*,—W. M. C. Fairfax, Walter Gwynn, John B. Jervis, Jonathan Knight, B. H. Latrobe, and W. G. McNeill.

C. Crozet declines his appointment as one of the Committee of seventeen, without expressing an opinion.

J. B. Jervis declines becoming a member of a society, formed on the principles of the proposed constitution.

Edward F. Gay declines becoming a member of any society of Civil Engineers.

Isaac Trimble, Sylvester Welch, and G. W. Whistler have made no reply to my circular.

I have been convinced, from the tenor of the letters received from different members of the Committee, that a *National Society*, on a broad and useful basis cannot be formed by gentlemen holding such discordant opinions, unless they will take the pains to meet together, and give the subject a fair discussion. The adjournment of the Committee in April was "sine die"; and those portions of sections 15 and 16, which fix a meeting in September next, and appoint a provisional Secretary until that time, fall to the ground with the body of the instrument.

Matters must consequently commence de novo, and additional correspondence will be necessary before a day of meeting can be selected.

I have hitherto cheerfully attended to the duties which the Baltimore Convention, and subsequently, the Committee imposed upon me, but as I now see no prospect of a beneficial result to the profession, and have no leisure for useless correspondence, I respectfully decline acting longer a

the organ of the Committee, and will hand over the papers and correspondence in my hands to any one they may designate.

Very respectfully,

EDWARD MILLER.

LIEUT. LE COUNT, ON RAILWAYS.

The mean receipts for five years on the Liverpool and Manchester line give the following proportions:—Revenue 100, expenses 55, profits 45; and the expenses have been as high, or higher than 60. The average, however, gives the ratio of revenue to profit at 1 to .45. On the Dublin and Kingston railway the same ratio for 26½ months gives 1 to .4344. On the Brussels and Mechlin railway the ratio for 1 year is 1 to .488. On the Grand Junction railway, for 6 months it is 1 : 48. On the London and Birmingham, no data exists to form a judgment. There is a very singular coincidence in these ratios on lines so very differently circumstanced, and of lengths varying from 6 miles to more than 100; but we have not yet acquired any sufficient experience in railway statistics to enable us to speak with confidence on the subject. If every railway would publish yearly its experience, as was so handsomely done by the Liverpool and Manchester for several years, analyzing every source of expense, and reducing them to the ratio per passenger and per ton per mile, we should then soon acquire such a stock of knowledge as would enable all these points to be decided; indeed, of so much consequence are railways now becoming, that the legislature should take up the question, making it a law that returns should be sent yearly, according to a form arranged by sone person thoroughly conversant with the subject.

The following extract shows the difficulties of obtaining an act of incorporation from Parliament; we have not in this country found similar embarrassments.

That these matters require the greatest consideration, will be apparent from the difficulty, delay and expense of obtaining acts of parliament for railways. The cost of that for the Liverpool and Manchester line, for instance, thirty miles, was about 900*l.* per mile. That for the London and Birmingham, 112 miles, was 72,869*l.* or 650*l.* 12s. per mile; and it is well known that the expense has reached 1000*l.* per mile on long lines, and that latterly, in every new session of parliament, there have been fresh difficulties thrown in the way of obtaining the necessary acts, till it is now nearly impossible to succeed at all.

There are many very great hardships connected with obtaining an act of incorporation for a railway. Parliament requires that a plan and section of every part of the ground through which the intended line is to pass, shall be lodged with their clerk, and with the clerks of the peace in every county through which the railway goes. This is a very proper regulation in order that every landholder may be able, by travelling a convenient distance, to have a personal inspection of a duly authorised document, so as to examine the nature and extent of the benefit, or the inconvenience which it may occasion to his particular property; but parliament should at the same time have given the railway companies the power of complying with this wholesome regulation, in the same way as road surveys are made in Ireland, by an order from two magistrates to enter any requisite grounds. This, however, is not done, and therefore it follows, as a necessary consequence, that the projectors of these undertakings, no matter how beneficial or important soever to the community at large, are left entirely at the mer-

cy of the landholders, whether they can make their survey or not. We have ourselves known, that when decided opposition has been evinced to the undertaking, the engineers and surveyors have been put to all possible shifts to obtain the necessary data for their plans and sections. Working by night with lanthorns has even been unavoidably resorted to; and in one case, where the proprietor was a clergyman, he was watched on Sunday until he went into his church, and a strong party immediately setting to work, just suceeded in finishing the business as he concluded his sermon.

The facilities of opposing a bill in parliament are so great, that every temptation is held out to do so, especially when the rich harvest to counsel, solicitors and witnesses, is considered; and as has been well observed by the Irish railway commissioners, discussions are mooted of the most discursive and discordant kinds, relating to all the abstract professional matter in the most distant manner connected with a railway. The principles of curves and gradients are entered into with mathematical precision, and the laws of friction and gravity are investigated; questions about which the counsel and the court are often equally ignorant, the one side seeking to swell the estimates and lower the profits, and the other pulling in the opposite direction, like the bulls and bears on the stock exchange, till at last, probably after the expenditure of thousands, the bill is thrown out, not on its own merits or demerits, but because, perhaps, a notice to the proprietor of five or six yards of a cabbage garden, was left next door by mistake.

The parliamentry rules are now as much too strict, as they were at first too loose. The time when the required plans and sections are to be deposited, is very inconvenient; two years at least being required between the deposits being paid and the act obtained. Thus at the present time, if any line is wished to be procured, the surveys must be made in the autumn of 1838, the plans must be lodged and the notices given in Mareh 1839, the petition for the bill presented to the Commons in February 1840, and supposing the act obtained the same session, little if any real work can be done until the spring of 1841.

It would seem that the same spirit, even in a greater degree, actuates landholders in England as in this country. The following plan of obtaining cessions may be useful to some of our readers.

While the engineer is employed in getting out the working drawings, &c., for the several contracts, the land-valuers will be using all their endeavors to get possession of the land in the order in which it is wanted. Public companies have been so grossly taken in on this head, and particularly railway companies, that it becomes imperative that something should be done at all hazards to protect their interests. We have ourselves seen the land for one of the principal railways just constructed, paid for at the enormous sum of 5,500*l.* per mile, and another at upwards of 330*l.* an acre or about 5600*l.* per mile, under all circumstances of fraud, delusion and downright robbery, that can any how be conceived. No means were left untried, no artifices unresorted to, and the most barefaced falsehoods unblushingly set forth in aid of one vast system of plunder from beginning to end, with hardly any exception. They understand these things better in America. Juries there have actually awarded that landholders should compensate railway companies for bringing the line through their lands; while in England, it is notorious that the consent of men of great influence has frequently been obtained as a matter of policy, by agreeing to pay them amounts totally out of proportion to the value of the land required; while others have purposely dissented, until they were bought off by a bribe. All these unnecessary extortions, as well as the enormous sums expended in order to

obtain acts of incorporation, come in most cases, ultimately out of the pockets of the public in the shape of heavier fares.

The first step in order to prevent this in other cases, will be to ascertain the fair value of the land, and of the requisite compensation, and whoever asks more than 25 per cent. above that value, hand him over to a jury that minute. If this course be in the beginning avowedly and unhesitatingly adopted, there is no doubt the interests of the company will at any rate be protected from those gross cases of pillage which have lately taken place.

In order to render this complete, the agent, or the land valuer, should be engaged with on the following terms:—Suppose 900 acres are required, and that if some greater precaution than has hitherto been taken be not put in force, then this land will average 300*l.* an acre, or the whole will cost 270,000*l.* Now, if the remuneration to the land valuer be made upon a scale which increases, while the price of the land decreases, the amount may stand as follows:—

Land valuer's pay per cent.	When the price is, or above per acre.	Total land-valuer's pay.	Saving to the compy.
¼	L.300	L.675	nothing.
½	275	1237½	22500
¾	250	1687½	45000
1	225	2025	67500
1¼	200	2500	90000
2	175	3150	112500
2¾	150	3712½	135000
4	125	4500	157500

The above per centage must only be paid in this way. For example, if the land, when totalled, is found to be between 200*l.* and 225*l.* per acre, then 1¼ per cent. is paid on a suppositious price, namely, 200*l.* per acre; when it is between 225*l.* and 250*l.* per acre, 1 per cent. is paid, rating it at 225*l.* per acre, and so in all other cases.

The scale of remuneration will require adaptation to peculiar circumstances; in fact, if the principle above laid down be adhered to, the details are immaterial; all that is necessary is by a bonus of 4000*l.* or 5000*l.* exciting the land valuer to the most rigid attention to economy, which, combined with a firm resistance to every attempt at extortion, will no doubt in most cases prevent the gross impositions which have been lately put in practice. The short-sighted land-holders, by their outrageous opposition, may have here and there driven a railway into a bad curve, but by causing so much discussion, they have mainly contributed to the rapid spread of the system.

The following extract in relation to excavation and embankment may be of interest to some of our readers.

There are several ways in which earth-work may be hastened, for instance, the use of locomotive and fixed engines to draw the earth along, both of which will be cheaper than horse-power; and as no very rapid speed is required for this work, a cheap description of locomotive engine might be constructed, fully able to take a train of earth wagons at the rate of eight or ten miles an hour, and not costing more than 700*l.* or 800*l.*—whereas a good passenger engine, made in the best manner, will cost 1500*l.* One large tube would be sufficient for all common purposes.

A common moveable steam-engine, working with a rope, will be cheaper than locomotive power, but not so convenient; if used, advantage should be taken in all cases of gravity. Loosening the ground with a plough, will be very advantageous where the soil will permit it, such as clay, marl, and sometimes shale; and as the quantity of work which can be done is limited by the tip, this must be paid every attention to. The usual mode, by running sidings out from the main line in the form of a fan, so to have as many tipping places as possible, requires modifying. At present the common practice is to take up and relay the rails as the embankment proceeds, which consumes a great deal of time, and gives a corresponding portion of trouble, instead of which, if longitudinal bearers are framed for each tipping place, these can be at once lifted up all in a piece, and carriad forward, and a rail put in behind them, in a very short space of time, and with one-fourth of the trouble which is found in the old way. When the embankment is not high, these frames may be supported from below on a railway, and be moved forward any length that may be required. A horse should be kept for tipping above, and he may take in three wagons at a time. By making the above frames to propel forward, and having a door in the bottom of the wagons, the quantity tipped may be very considerably increased.

Whenever the lead gets above 1½ miles, and there is much to do, a locotive engine should be employed, the expense of which, including fuel, wages repairs, interest on capital, and provision for a renewal every five years, will not exceed 4*l.* per day; the engine will take 24 wagons per trip, at 10 miles per hour, while a horse taking 3 wagons will only go 15 or 16 miles per day. That a great saving will ensue is clear, and may be thus shown. Let the lead be two miles, and the contractor required to tip 1200 cubic yards per day; this would require 150 two-yard wagons, besides spare ones and as a horse with three wagons would make four trips per day, or 24 yards per day, $\frac{1200}{24}$=50 horses, besides spare ones and tipping horses.—Now these wagons are to be constantly travelling, and to keep these going there must be 24 always filling, and 24 tipping. This, with the requisite number of spare ones, will in the whole require about 220 wagons; whereas, with the engine, 24 travelling, 24 filling, 24 tipping, and 24 spare, total 96, is all that is required, say 100. Here then is a saving of 120 wagons at 20*l.* each, or 2400*l.*, which is considerably more than the cost of the engine, besides the 50 horses, which, with their harness, cannot be taken at less than 25*l.* each, or 1250*l.*

Again, take 50 horses' keep at 3s. per day, is 7*l.* 10s.; 50 boys at 1s. 6d., or 25 men going one to two trains, at 3s. is 3*l.* 15s., total 11*l.* 5s. per day, whereas the engine will not cost more than 4*l.* Under very unfavorable circumstances, a mean of 15,000 trips gave for a distance of 1969 yards, 15 wagons per train, carrying 25 cubic yards, with a consumption of coal of 245 lbs., costing 2s. 4d., wages, 11¼d., repairs and sundries, 6¼d., total 3s. 9¾d. per trip.

The old way of working at the face of an excavation, and bringing it out by lifts, is now known to be more tedious, and consequently unprofitable, than running a gullet through at once, in which as many wagons as the contractor likes can be put in and filled, both by throwing in the earth from above, or having a stage over the wagons to run barrows on. To get the greatest quantity of earth, besides ploughing it, which plough may be often worked by a steam engine, the method called "falling" may be resorted to, that is, digging underneath and then splitting it on the top with wedges, and with the help of long iron levers, bringing down a lump containing several cubic yards at once.

The contractor will find it best to provide wagons, engines and rails, and to sub-let his labor to small gangs of about a dozen men each and a ganger. The best sort of rails for a contractor's use is the T rail, inverted so that the lower flang nails down on the sleeper, and requires no chair. 30 lbs. per yard will be enough, but from 40 to 50 lbs. is better, as these will do for anything, and 30 lbs. would be too light for clayey soils.

In any place where time is an object, the tip end of the embankment ought to be made much wider and steeper than it is intended, so as to get in more roads at the tip; and as the work proceeds, this extra width is pared off and thrown down below to increase the slope, which should be left a little too narrow at the bottom on purpose.

There is another mode of increasing the tip, by which the time of forming a large embankment may be reduced one-half. This method is to form the embankment at twice in the following manner:—Carry out the earth to the required width, say 20 feet high, and then come on and complete this with a second set of tipping places, say for 30 feet more in height; the wagons must run from the 50 feet level down to the 20 feet by means of inclined planes on both sides of the upper embankment, and from the width of the lower one, a great many roads may be put in at the tip; the upper part of the embankment is brought on in the usual way, and by this means the quantity tipped may be doubled.

Under favorable circumstances, a contractor ought to move 1000 cubic yards of earth per day at each trip, and this by the above process may be doubled, in fact the limit is the tipping, for, by running a gullet into the hill getters and fillers may be placed as thick as will leave them room to work, the quantity of which depends greatly on the weather, the average number of working days being from 200 to 230, in which may be got, by having night shifts in summer, and 3, 6 and 9 hours' shifts in spring and autumn, about 3000 working hours. Under many peculiar circumstances, it will be very advantageous to lay in a line of rails, and place huts on it for the workmen on wheels; so that their place of abode always follows up, and is close to their work, in fact a moveable village. Much, of course, also depends on the nature of the soil, as to the work which will be done in this time; generally a filler will put into a wagon from 15 cubic yards per day in stiff clay, to 25 cubic yards per day in loose sand, and by falling the earth as before described, 1 getter will keep three fillers going, so that to keep up 1000 cubic yards per day, will take from 60 to 90 men according to the nature of the ground.

Where there is much rock the natural stratification of it should be closely examined and attended to in the blasting of it, as a horizontal blast would in many cases bring down ten times as much as a vertical one, and the force of the powder will be increased by mixing saw-dust with it. The strength and disposal of the blasts must entirely depend on the nature of the rock, and also in some measure, on whether it can be used in the bridges, or other erections along the line.

The contractor will find it his interest to look out sharp for clay, and either to make his own bricks, or let his clay to a respectable brickmaker to make them for him, unless he happens to be very favorably situated as to carriage; he should also do all his wagon repairs, erecting temporary carpenters' and smiths' shops in some position adjacent to his heaviest work, but being careful they are so situated that they can be let or sold at the termination of his contract; he should always work towards his greatest job, and of course so apportion his men as to bring in the whole at one time at the end.

It may sometimes happen, that from unavoidable causes, a contractor

will find it impossible to continue his work, and occasionally this will be done intentionally. To guard against the last has been already adverted to, but to guard against the first is morally impossible; for there are so many cases in which a man, with the very best intentions, is yet borne down by the uncontrollable force of circumstances, that no human foresight can by any possibility prevent an unfavorable result. As a general rule, it will be best for the directors, in every prudent way, to assist and encourage a contractor, and by every means in their power to enable him to complete his work, provided it be seen that he really is desirous to get on. If prices have risen against him, or if he has made a miscalculation, it will be most decidedly the best thing for the company to increase the amount, to remit his retained money, or by any means to get him to finish his contract. If this be not done, the consequences will be very uncomfortable. His inability will have first become manifest by his employing too few workmen. If the checks which we have explained be put in force this is seen at once. He is served with a legal notice, that under the contract, the company will employ men if he does not, and charge their expenses against him. This will probably induce him to come forward and state what his difficulties are; then if the company do not assist him, he will tell them he must give up his contract; he is perhaps, a man of no capital, and his sureties are the same, so that the company have no resource but to take the work into their own hands. In the mean time, the work having fallen in arrear, there comes the tedious admeasurement of what has yet to be done, and two or three weeks' squabbling between his lawyer and the company's, as to the terms on which he is to give up the works, and perhaps references to umpires, each taking a week; then the company have to order wagons, engines, and tools of all kinds, and to find foremen, overseers, sub-contractors, and workmen, all at a vast expense, it being the fate of almost every public company to be charged higher than individuals. While all this is going on, the work is so much delayed that the line cannot be opened at the time which was intended, the proprietors loosing the whole proceeds. Then come the enormous expenses which are requisite to redeem the time as much as possible. Land has to be bought to make side-cuttings in order to form the embankments, and, in another place, to deposit the earth from the excavation, which is now to a great extent thrown into spoil; horse-runs are established at as many places as possible, to bring up the earth in barrows, and all this in addition to the regular work at the gullet and the tip; and when these things are taken into consideration, it will at once be seen, that the company ought never to agree to finish the work themselves, but as a dernier resort. There are on one of the railways in England, six contracts which were let for 600,000*l*., and which the company have had to take into their own hands at an expense of 1,200,000*l*. In one instance, the cost of the contract was more than trebled so that any means should be resorted to in order to assist the contractor through his job; and we again repeat, that it is decidedly bad policy to take the lowest tender in letting the contracts. A man of character alone should be selected, and ought to receive every encouragement in the execution of his work.

THEORY OF THE STEAM-ENGINE.

(Continued from page 32.)

In the calculations relative to locomotive engines we shall introduce three terms more: the first to express the resistance of the air against the train in motion, a force which, increasing in the ratio of the square of the velocity could not be neglected without error; the second to represent the resistance offered by the engine itself in the transport of its own weight on the rails;

and the third to take account of the force expended by the engine in animating its fire, according to the method in use in those engines. But as these divers circumstances do not in general occur in stationary engines, we will omit them at present, it being easy to reproduce them in the particular cases as it may become necessary.

From what has just been said, the resistance R may be replaced by

$$R=(1+\delta)r+p+f.$$

We shall then substitute this value in that of v, and at the same time make

$$\frac{l'}{l'+c}+\log\frac{l+c}{l'+c}=k;$$

an expression, which in the case of $l'=l$, that is to say, for unexpansive engines, reduces itself simply to the ratio $\frac{l}{l+c}$. Then, the value of v will become

$$v=\frac{S}{a}\cdot\frac{k}{n+q\overline{R}},$$

or

$$v=\frac{S}{a}\cdot\frac{k}{n+q\{(1+\delta)r+p+f\}} \quad . \quad . \quad . \quad (1)$$

It will be remarked that the quantity

$$\frac{S}{n+q\overline{R}}$$

is nothing else but the *absolute* volume of the steam correspondent to S, in contact with the liquid at the pressure R. Therefore, to have the velocity v, we must calculate the volume of the steam which corresponds to the volume of water S, supposed immediately transformed into steam at a pressure equal to the resistance R, afterwards divide that volume by the area a of the piston, and lastly, multiply the quotient by the quantity k, of which we have a little before given the developed expression.

The formula (1) contains the general relation between all the data of the problem, and will serve us to solve successively the different questions we have proposed elucidating. It will, however, be observed that the homogeneity of the formula requires that the dimensions of the engine a, l and l' be expressed in the same unit as the volume of water evaporated S, and that the pressures per unit of surface P, r, and p, be also referred to the same unit as S. We mention this circumstance because these various quantities are usually referred to different units, according to what may be, in practice, the most convenient manner of expressing each.

Besides, from the mode of our reasoning itself, it is to be understood that the quantity S, in the equation, is the *effective* evaporation of the engine; that is, it represents the volume of water which really enters the cylinder in the state of steam, and there acts upon the piston. If then, from any mode of construction of the engine, it should occur that a portion of the steam generated in the boiler, escape without acting on the piston, that portion is not to be considered as included in the quantity S, and ought, therefore, to be deducted before all calculation.

The formula just obtained will give the velocity of the piston for any load r, when the dimensions and different data of the engine contained in the equation are known. This formula is general, and applies to every kind of rotative steam-engine. If the engine be expansive, it will suffice to replace l' by the length of the stroke traversed when the steam begins to be intercepted; if the engine be unexpansive, it will suffice to make $l'=l$. If there be condensation, p, must be replaced by the pressure of condensation; and if the engine be not a condensing one, p is to be replaced

by the atmospheric pressure. However, before making these deductions relative to the different systems of engines, we shall continue to seek the general formulæ for all the problems we have undertaken to solve.

Let it only be observed, that the velocity of the piston in a given engine, is totally independent of the pressure at which the steam is formed in the boiler, and that, on the contrary, it depends essentially on the evaporation S of the boiler per unit of time, and on the total resistance $[(1+\delta)r+p+f]$ opposed to the motion of the piston.

Section III.—Of the load of the engine, for a given velocity.

The analogy we have just obtained will show reciprocally the reistance a known engine can set in motion at a determined velocity. In effect, it suffices to draw from it the value of r; or rather, as r is only the resistance per unit of surface of the piston, it will be preferable to have the whole resistance, by taking immediately the value of $a \times r$, that is,

$$ar = \frac{Sk}{(1+\delta)qv} - \frac{a}{1+\delta}\left(\frac{n}{q}+p+f\right) \quad . \quad . \quad . \quad . \quad (2).$$

From the form of this expression, it would appear at a first glance, that on making $v=0$, that is, on supposing the velocity null, the result would be an infinite load; but on examining the formula more attentively, we soon perceive that the result would by no means be such.

In effect, if $v=0$, it follows also that $S=0$; for S is the quantity of steam which effectively traverses the cylinders in a unit of time; and no quantity of steam whatever can traverse the cylinders without moving the piston, and consequently creating some velocity in the engine. If, then, the velocity be supposed equal to zero, we must necessarily have at the same time $S=0$. But, making at once $v=0$ and $S=0$, we find

$$ar = \frac{0}{0},$$

and not $ar=\infty$, as it first appeared.

Thus, in this case, the formula reduces itself to the indeterminate form; but it is to be observed, that the present formulæ give the effects of the engine, only after the uniform motion has taken place. Now we shall presently see that, for a given evaporation S, the uniform velocity can never be less than

$$v' = \frac{mS}{a} \cdot \frac{l}{l'+c};$$

since it is that which corresponds to the passage of the steam into the cylinders, at its state of greatest density, and that at any other density, that steam would form a larger volume, and consequently could not traverse the cylinders in the same time, without producing a greater velocity. All supposition of less velocity than this, is then inadmissable in this problem, as being incompatible with that state of uniformity of motion, for which alone the effects of machines are calculated.

Section IV.—Of the evaporation of the boiler, to produce wanted effects.

To find the evaporation of which an engine ought to be capable, in order to set in motion a certain resistance r at a known velocity v, the value of S must be drawn from the same equation,

$$S = av\frac{n+q\{(1+\delta)r+p+f\}}{k} \quad . \quad . \quad (3)$$

This equation gives the quantity of water the engine ought to be capable of evaporating and transmitting to the cylinder per minute. It will then be easy, according to the mode of construction intended to be used for the boiler, and the practical data proper to estimate the quantity of water

evaporated by such form of boiler, to know what extent of heating surface should be given to the boiler of the engine, in order to obtain the proposed effects.

As the quantity S represents here the effective evaporation disposable by the engine, it is understood that, if the usual construction of the engines under consideration give rise to a certain loss of steam, either by safety-valves or otherwise, account of this must be taken, with as close an approximation as possible, by first adding that loss to the quantity S deduced from the preceding equation, then by estimating the heating surface suitable to the production of the useful steam augmented by the lost steam.

Section V.—Of the different expressions of the useful effects of the engines.

1. The useful effect produced by the engine in the unit of time at the velocity v, is evidently $a\,r\,v$, since the velocity v is at the same time the space traversed by the piston in a unit of time. Consequently, by multiplying both members of equation (2) by v, we shall have the useful effect;

$$\text{u. E.} = a\,r\,v = \frac{Sk}{(1+\delta)q} - \frac{a\,v}{1+\delta}\left(\frac{n}{q}+p+f\right) \quad . \quad . \quad . \quad (4)$$

This may be expressed in terms of the load, by multipying the two members of equation (1) by $a\,r$. We have then for the useful effect the engine may produce with a given load,

$$\text{u. E.} = arv = \frac{S\,r\,k}{n+q\{(1+\delta)\,r+p+f\}} \quad . \quad . \quad . \quad . \quad . \quad (4\text{ bis})$$

It will be remarked, that in a given engine this useful effect does not depend on the pressure at which the steam is generated in the boiler, since the quantity P does not appear in the above equations; but that it depends essentially on the evaporation S effected by the boiler in a unit of time.

2. If it be required to know the horse-power which represents the effect of the engine, when working at the velocity v, or when loaded with the resistance r, it suffices to observe that what is called one-horse-power represents an effect of 33,000 lbs. raised one foot per minute. All consists then in referring the useful effect produced by the engine in the unit of time, to the new measure just chosen, that is, to the power of one horse; and consequently it will suffice to divide the expression already obtained in equation (4) by 33,000.

Thus the horse-power of the engine, at the velocity v, or with the resistance r, will be

$$\text{u. HP.} = \frac{\text{u. E.}}{33000} \quad . \quad . \quad (5)$$

We will here observe, that what is designated by *horse-power* would, with much more propriety, be termed *horse-effect*, since it is an effect and not a force. It should then be said, that an engine is of so many horse-effect, instead of saying that it is of so many horse-power.

3. In the two preceding questions, we have expressed the power of the engine from the total effect it is capable of developing, without regard to its consumption of fuel or water. We are now about to express the same, either from the effect it produces per unit of fuel or of water expended; or from its consumption while performing a given work.

The useful effect obtained in equation (4), is that which is produced by the volume S of water transformed into steam; and as that volume of water S is evaporated in a unit of a time, the result is, as has been said, the useful effect produced by the engine in a unit of time. But if it be supposed that during the unit of time, there be consumed N pounds of fuel, the useful effect produced by each pound of fuel will plainly be the Nth part of the above effect.

Hence the effect arising from the consumption of 1 lb. of fuel will be

$$\text{u. E. 1 lb. co.} = \frac{\text{u. E.}}{\text{N}} \quad . \quad . \quad . \quad . \quad . \quad (6)$$

To apply this formula, it suffices to know the quantity of fuel consumed in the furnace per minute, that is to say, while the evaporation S is taking place. This datum may be determined by a direct experiment on the boiler itself, or by analogy with other boilers similarly disposed. And the datum once obtained, may be used for every other case, and for every supposition of velocity of the engine.

4. We have seen above, that the effect indicated by u. E. is that which is due to the volume of water S transformed into steam. If then it be required to know the useful effect arising from each cubic foot of water, or from each unit of the volume S, it will obviously suffice to divide the total effect u. E. by the number of units in S. Thus, for the useful effect due to the evaporation of one cubic foot of water in the engine, we have

$$\text{u. E. 1 ft. wa.} = \frac{\text{u. E.}}{\text{S}} \quad . \quad . \quad . \quad . \quad (7)$$

5. we have obtained above the useful effect produced by one pound of fuel. It consequently becomes easy to know the number of pounds of fuel which represent any given useful effect, as, for instance, one horse-power. A simple proportion is, in fact, enough, and we have for the quantity, in weight, of fuel requisite to produce one horse power,

$$\text{Q. co. for 1 hp.} = \frac{33000\ \text{N}}{\text{u. E.}} \quad . \quad . \quad . \quad . \quad (8)$$

6. By a simple proportion will also be found the quantity of water that must be evaporated, in order to produce one horse-power, viz.:

$$\text{Q. wa. for 1 hp.} = \frac{33000\ \text{S}}{\text{u. E.}} \quad . \quad . \quad . \quad . \quad (9)$$

7. It may yet be required to know what horse-power will be produced by a pound of coal; which will evidently be

$$\text{u. HP. for 1 lb. co.} = \frac{\text{u. E.}}{33000\ \text{N}} \quad . \quad . \quad . \quad . \quad (10)$$

8. Finally, the horse-power produced by the evaporation of 1 cubic foot of water will likewise be

$$\text{u. HP. for 1 ft. wa.} = \frac{\text{u. E.}}{33000\ \text{S}} \quad . \quad . \quad . \quad . \quad (11)$$

Substituting, then, in these several equations for u. E. its value determined by the formula, (4,) we immediately deduce the numerical solution of the proposed problems.

Sec. VI.— Table for the numericle solution of the formulæ (rotative engines.)

As the formulæ we have just obtained, and those which are about to follow, contain hyperbolic logarithms, the use of which is inconvenient, we here subjoin a table which gives, without calculation, the principal elements of the equations, and will greatly simplify the matter.

In this table we have supposed the clearance of the cylinder $c = \cdot 05\ l$, as is the case in rotative steam-engines, of which we are now treating. In single-acting engines the clearance of the cylinder, including the adjoining passages, amounts to ·1 of the stroke, because the motion of the piston not being limited by a crank, is it more liable to strike the bottom of the cylinder.

We have not inserted in the table a column to represent the fraction

$$\frac{l' + c}{l}$$

because it is evident that $\frac{l'}{l}$ being known by the first column, the fraction

$$\frac{l'+c}{l}$$

will be equal to the former augmented by $\frac{c}{l}$, that is, by ·05.

Table for the numerical solution of the formulæ (rotative engines.)

Portion of stroke performed before the expansion, or value of the fraction $\frac{l'}{l}$	Corresponding value of the fraction $\frac{l}{l'+c}$	Corresponding value of k, or of the expression $\frac{l'}{l'+c}+\log\frac{l+c}{l'+c}$	Portion of stroke performed before the expansion, or value of the fraction $\frac{l'}{l}$	Corresponding value of the fraction $\frac{l'}{l'+c}$	Corresponding value of k, or of the expression $\frac{l'}{l'+c}+\log\frac{l+c}{l'+c}$
·10	6·667	2·613	·51	1·786	1·539
·11	6·250	2·569	·52	1·754	1·523
·12	5·882	2·526	·53	1·724	1·507
·13	5·556	2·485	·54	1·695	1·491
·14	5·263	2·446	·55	1·667	1·476
·15	5·000	2·408	·56	1·639	1·461
·16	4·762	2·371	·57	1·613	1·445
·17	4·546	2·336	·58	1·587	1·431
·18	4·348	2·301	·59	1·563	1·417
·19	4·167	2·268	·60	1·539	1·402
·20	4·000	2·235	·61	1·515	1·388
·21	3·846	2·203	·62	1·493	1·374
.22	3·704	2·173	·63	1·471	1·361
·23	3·571	2·142	·64	1·449	1·347
·24	3·448	2·114	·65	1·429	1·334
·25	3·333	2·085	·66	1·409	1·321
·26	3·226	2·059	·67	1·389	1·308
·27	3·125	2·032	·68	1·370	1·295
·28	3·030	2·006	·69	1·351	1·282
·29	2·941	1·980	·70	1·333	1·269
·30	2·857	1·955	·71	1·316	1·257
·31	2·778	1·931	·72	1·299	1·240
·32	2·703	1·908	·73	1·282	1·233
·33	2·632	1·884	·74	1·266	1·221
·34	2·564	1·862	·75	1·250	1·210
·35	2·500	1·840	·76	1·235	1·297
·36	2·439	1·818	·77	1·220	1·186
·37	2·381	1·797	·78	1·205	1·175
·38	2·326	1·776	·79	1·191	1·164
·39	2·273	1·755	·80	1·177	1·152
·40	2·222	1·736	·81	1·163	1·141
·41	2·174	1·716	·82	1·149	1·131
·42	2·128	1·697	·83	1·136	1·119
·43	2·083	1·678	·84	1·123	1·109
·44	2·041	1·660	·85	1·111	1·099
·45	2·000	1·642	·86	1·099	1·088
·46	1·961	1·624	·87	1·087	1·078
·47	1·923	1·606	·88	1·075	1·067
·48	1·887	1·589	·89	1·064	1·057
·49	1·852	1·572	·90	1·053	1·047
·50	1·818	1·555			

We limit ourselves to the preceding problems, because they are those which are most commonly wanted; but it is obvious that, by means of the same general analogies, any one of the quantities which appear in the problem may be determined, in case that quantity should be unknown, and that it were desired to determine it according to a given condition. Thus, for instance, might be determined the area of the piston, or the pressure in the boiler, or the pressure of condensation, &c, corresponding to given effects of the engine, as we have done for locomotive engines, in a preceding work (TREATISE ON LOCOMOTIVES.) But as these questions rarely occur, and as they offer no difficulty, we deem it sufficient to indicate here the manner of obtaining their solution.

ARTICLE II.

OF THE MAXIMUM OF USEFUL EFFECT WITH A GIVEN EXPANSION.

Section I.—Of the velocity of maximum useful effect.

The preceding problems have been solved in the most general way, tha is to say, supposing the engine to set in motion any load whatever at any velocity whatever, with the single condition that the load and velocity be compatible with the power of the engine. In constructing an engine for a determined object, or to move a certain load with a given velocity, it must not be planned in such manner as to require the greatest effort of which it is capable, to perform that task which is to be its regular work; for in that case, it would have no power in reserve, to meet whatever emergencies may occur in the service. On the other hand, since the maximum effort of the engine with a given expansion, corresponds, as we shall presently see, to its maximum useful effect, it follows that we are not to expect regularly from the engine its maximum of useful effect, nor can the engine be constructed with such pre-intention. It is necessary, however, when an engine is constructed, or to be constructed, to know what is the velocity at which it will produce its maximum useful effect, and what this maximum useful effect will be; for it is evidently that knowledge which must decide the regular working load of the engine, and mark the possible limits of its effects in case of emergency.

What is that velocity or that load, most advantageous for the work, and what are the divers effects which will then be produced by the engine? This is what now remains to determine, first, in supposing the expansion of the engine fixed *a priori*, that in making that expansion itself to vary, in order to obtain a further increase of effect.

To know the velocity corresponding to the greatest useful effect, it suffices to examine the expression of the useful effect produced by the engine under any velocity whatever, namely, (equa. 4):

$$\text{u. E.} = \frac{Sk}{(1+\delta)q} - \frac{av}{1+\delta}\left(\frac{n}{q}+p+f\right).$$

It is observable here, at the first glance, that since the velocity enters only into the negative terms, the less that velocity is, *for a given expansion*, the greater will be the useful effect of the engine. On the other hand, referring to the expression of the velocity of the engine under a given load, before having substituted for P′ its numerical value, viz. (equa. B):

$$v=\frac{S}{a(n+qP')}\cdot\frac{l}{l'+c},$$

we perceive that the velocity is the smallest possible, without loss of steam, when P′ is the greatest; and as P′, which is the pressure of the steam in the cylinder, can in no case exceed P, which is the pressure in the boiler, the condition of the minimum velocity, or of the maximum useful effect, will be given by the equation P′=P, or

$$v'=\frac{S}{a(n+qP)}\cdot\frac{l}{l'+c}\quad\ldots\quad(12)$$

Expressing by m the volume of the steam under the pressure P, referred to the volume of the same weight of water, this formula may, from equation (a) take the form

$$v'=\frac{mS}{a}\cdot\frac{l}{l'+c}\quad\ldots\quad(12\text{ bis})$$

In this manner the calculation of the term $(n+qP)$ is avoided, since the quantity m is given by the tables of Chapter II., and may thence be taken with greater accuracy than from its approximative value

$$m=\frac{1}{n+qP}.$$

This observation will equally apply to all the following formulæ, wherein the quantities n and q recur united under the form $(n+qP)$.

It is to be remarked, with respect to the preceding formula, that, mathematically speaking, the pressure P′ can never be quite equal to P. In fact, since there exist pipes between the boiler and cylinder, through which the steam must pass, and that the passages of those pipes form an obstacle to the free motion of the steam, there must necessarily be, on the side of the boiler, a small surplus of pressure equivalent to the resistance of the obstacle in question; otherwise the motion of the steam could not take place. This surplus of pressure, then, on the side of the boiler, prevents P′ from becoming mathematically equal to P, and thus the real velocity will always be rather greater than v'. The difference between P′ and P (we mean the difference merely arising from the obstacle just mentioned) will be by so much the less, as the area of the passages is larger and their way more direct; but as, with the dimensions of ordinary use in steam-engines, that difference is very trifling, we shall not notice it here. Seeking it, in fact, by known formulæ for the flowing of gasses, we find that it is hardly appreciable by the instruments used for measuring the pressure in the boiler; consequently, to introduce them into the calculation would only complicate the formulæ, without rendering them more exact.

To return to the inquiry before us, the maximum useful effect will be given by the condition P′=P, or

$$v'=\frac{S}{a(n+qP)}\cdot\frac{l}{l'+c}.$$

This is, then, the velocity at which the engine must work, in order to obtain the greatest effect possible; and the equation P′=P shows reciprocally, that, when that velocity takes place, the steam enters the cylinder at full pressure, that is, nearly at the same pressure which it had when in the boiler.

(To be continued.)